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STRATA CONTROL INVESTIGATIONS IN THE SYDNEY COALFIELD

Quarterly Report June 30, 1983.

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Cape Breton Coal Research Laboratory

January 1984

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STRATA CONTROL INVESTIGATIONS IN THE SYDNEY COALFIELD

Quarterly Report June 30, 1983

by

Tim Aston* and Peter Cain*

SUMMARY

This report reviews the progress and results of strata control investigations in the Sydney Coalfield for the period April 1 to June 30, 1983. Its purpose is to present details and results of field investigations implemented within the coalfield to update progress on current research activities and to identify areas for future research.

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ÉTUDES SUE LR CONTRÔLE DU TOIT DANS LE BASSIN HOUILLER DE SYDNEY

Rapport trimestriel, le 30 juin 1983

par

Tim Aston* et Peter Cain*

RÉSUMÉ

Le rapport examine l'avancement et les résultats des études de contrôle du toit dans le bassin houiller de Sydney pour la période allant du 1er avril au 30 juin 1983. Il a pour objectif de présenter les détails et les résultats des études sur le terrain entreprises dans le bassin houiller en vue de mettre à jour la situation des travaux de recherches en cours et d'identifier d'autres dommaines de recherches ultérieurs.

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INTRODUCTION

In the period April 1 to June 30, 1983 the Cape Breton Coal Research Laboratory (CBCRL) has continued to expand its activities in the collieries of the Cape Breton Development Corporation (CBDC). The major impetus of the last three months has shifted from gateroad deformation studies to a wide variety of investigations at the three producing collieries.

The most important new piece of work is the initiation of the photographic survey of gateroads at Lingan and No. 26. This forms the initial phase of a proposed Barrier Pillar Study Project currently being planned (1). Ultimately, this will involve the instrumentation of a barrier pillar to measure its performance during extraction operations, leading to more accurate calculation of barrier pillar widths required to maintain gateroad stability.

Also of interest is the programme of instrumentation trials proposed at Prince mine for two new types of instrumentation, which are at present undergoing certification by EMR. The trials are expected to be complete by the end of the year.

In addition to these topics, floor properties testing, the continued occurrence of roof falls at Prince mine and 'Swellex' bolt testing at No. 26 are described. Current CBCRL involvement in the Donkin-Morien project, a long term subsidence monitoring programme and the application of geostatistical techniques to the Sydney Coalfield is also discussed.

LINGAN MINE

Two problems were addressed during investigations at Lingan mine. Firstly, the problem of supporting a coal face line after the removal of powered supports in order to maintain the return air ventilation in a cundy-style ventilation layout and secondly, the problem of barrier pillar design. Progress made in both fields is described as follows:

MAINTAINING LONGWALL FACE OPENINGS

Investigations were carried out on 6E face line to determine the resistance offered by the hardwood chocks installed as the permanent support system after the removal of the hydraulic supports. These investigations form the basis of a separate report (2), which is summarized below.

Assuming the detached roof block theory of support loading applies, the support required to maintain the face opening can be calculated. From closure measurements taken on the 6E face line after the installation of hardwood chocks, estimates of support resistance were made by deriving chock loading from stress/strain curves published by Zorychta (3). The results indicate that the current support methods are inadequate and that further work is required to assess the support requirement.

BACK ANALYSIS OF BARRIER PILLAR BEHAVIOUR

As a prelude to the initiation of a major research programme into barrier pillar behaviour and design, the process of back analysis of existing barrier pillar behaviour began at Lingan Colliery in late June 1983.

The work involves a photographic survey of every accessible gateroad, obtaining the following measurements:

1) roadway heights every 10 arches
2) roadway widths and a photographic arch profile every 50 arches
3) the position of colliery survey marks with respect to the photographic survey arches

By July 31, 1983 it is expected that all gateroads at Lingan Colliery will have been surveyed.

From the roadway heights obtained, details of convergence rates at the face end and further down the gateroads can be determined. By comparing convergence data with mine plans, depth of cover and proximate geology can be ascertained.

Arch profiles determined from photographic surveys will enable a preliminary analysis of the form of roadway deformation, and an understanding of the variation in cross section along the gateroads. This information will also be used by the ventilation research group of CBCRL.

An example of the change in arch profiles recorded in the materials level of the 2W coalface (now abandoned) is illustrated in Figure 1. Further analysis of the survey results is now underway.

PRINCE MINE

Activities at Prince Mine in the last three months have included a preliminary testing of floor strata properties and the preparation of an instrumentation trials programme. In addition, a further incidence of unstable roof resulting in a roof fall on the No. 3 Deep was examined.

FLOOR PROPERTIES TESTING

As indicated in the previous quarterly report, floor samples from various locations at Prince mine were collected for testing. Some samples were sent to Jacques, Whitford and Associates in Halifax, whilst others were tested at CANMET, MRL, Bells Corners in Ottawa. Sample locations at Prince mine are shown in Figure 2. The tests conducted and the testing laboratory are indicated in Table 1.

Summary of Test Results

The results of the testing are summarized and presented in Table 2. The numbers of samples tested in each suite varies due to difficulties in selection and preparation.

Discussion

Since the test results were completed, the CBDC Geological Department has determined that two types of strata immediately underlie the coal at Prince mine. At the drift portals, approximately 15 cms of mudstone below the coal rests on a hard siltstone. Further down the drifts, the thickness of mudstone decreases, until it disappears just above the start of the longwall section.

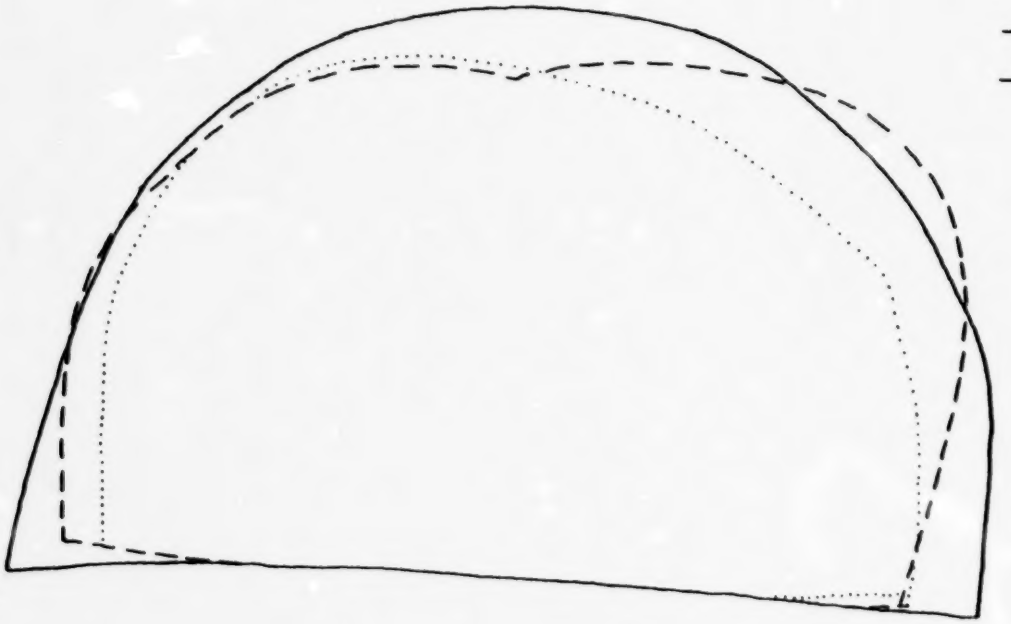

Fig. 1 Change in Arch Profiles, 2W Material Level, Lingan Colliery

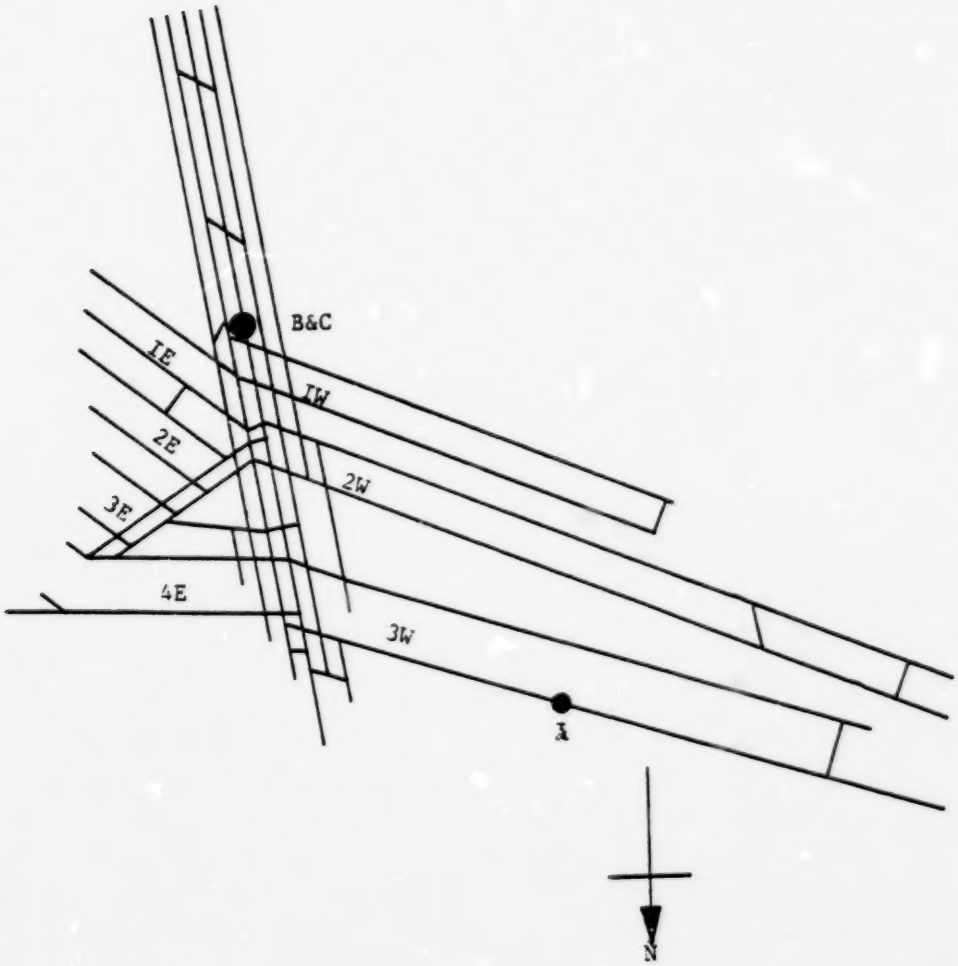

Fig. 2 Sample Locations, Prince Mine

Test	No. of Tests Suite A	B	C	Testing Laboratory
Triaxial Properties	2	-	-	MRL OTTAWA
Uniaxial Properties	1	-	-	
Triaxial Properties of Recompacted Material	1	1	1	JACQUES WHITFORD AND ASSOCIATES
Water Content	8	5	7	
Porosity	5	5	5	
Density	5	5	5	
Slake Durability	6	3	3	
Point Load Test	11	1	5	
Brazilian Tensile	10	-	-	
Optimum Moisture Content	1	1	-	
Maximum Dry Density	1	1	-	
Ultrasonic Elastic Constants	3	-	-	DALHOUSIE UNIVERSITY
Optical Mineralogy	2	2	2	
X-Ray Diffraction	2	2	2	NOVA SCOTIA RESEARCH FOUNDATION CORPORATION
Differential Thermal Analysis	2	2	2	

Table 1. Tests Conducted on Floor Samples from Prince Mine Locations A, B and C

Ultrasonic Elastic Constants (Sample A Only)	E = 21GPa G = 7.9GPa = 0.34	
Triaxial Properties (Sample A Only)	Angle of Internal Friction (Ø) Cohesive Strength Compressive Strength Tensile Strength	35° 10MPa 50MPa 5MPa
Uniaxial Strength Properties (Sample A Only)	Compressive Strength Poissons Ratio Youngs Modulus (E) Length/Diameter	63.3 MPa 0.18 17.9 GPa 1.95

	SERIES A	SERIES B	SERIES C
Triaxial Properties of Recompacted Material	Ø = 33.5° E*= 27.13	Ø 33.6 E* 28.69	-
Water Content	2.3%	3.9%	4.2%
Porosity	5.9%	10.72%	11.16%
Density	2.49g/cc	2.43g/cc	2.39g/cc
Slake Durability	96.7%	86.8%	59.6%
Point Load Test**		27.9MPa	8.82MPa
Brazilian Tensile	2.15MPa		
Optimum Moisture	14.3%	16.9%	
Maximum Dry Density	18.2g/cc	1.65g/cc	
Optical Mineraology Quartz: Clay Ratios	4.45	0.97	0.5
X-Ray Diffraction*** Mineralogical Analysis	α - quartz Kaolinite Montmorillonite	as A	as A
Differential Thermal Analysis	Reactions masked by Combustion of Organics		

* Average of last compression cycle values
** Corrected to MPa using CANMET Pit Slope Manual formula
*** Only qualitative analyses were achieved

Table 2. Summary of Results from the Testing of Prince Mine Floor Samples

Sample suite A was collected from an area where the coal rests directly on the siltstone, whilst suites B and C were collected from an area where the mudstone band persists. This is reflected in the differing quartz:clay ratios for the three samples.

Water contents and porosity (A<B<C), and also density (A>B>C) reflect the increased exposure to moisture and swelling effects and the higher quartz contents of the different suites of samples.

The slake durability index of suite A indicates resistance to weathering, but suites B and C already partially weathered showed less resistance. Suite C, the most weathered samples, had the lowest slake durability index.

As expected, available data for Point Load Indeces shows that suite A was strongest, and suite C weakest.

Results from the soils properties testing of suites A and B (not enough material of suite C was collected) were inconclusive, although it appears that a satisfactory test method was developed. The results of triaxial testing of suite A recompacted material compares favourably with those obtained from solid sample suite A specimens, giving some confidence in the results obtained for the recompacted material tests on suite B.

Too few tests were conducted in this first series to draw any firm conclusions, although the direction of future testing will be determined on the basis of these results and discussions with CBDC geological staff.

INSTRUMENTATION TRIALS

CBCRL has recently acquired two new instrumentation types, an extensometer and a convergence meter. In order to assess the function and suitability of these instruments, a field test programme at Prince mine will be undertaken as soon as both the instruments have received EMR certification. Both instruments are described, as well as the proposed test programme.

Irad Gage Sonic Probe Extensometer

Irad Gage Limited of Lebanon, New Hampshire, have recently released an extensometer system of simplicity and elegance which is available with MSHA approval for use in underground coal mines and is currently awaiting EMR approval.

An access tube runs up a borehole through magnetic reference points anchored to the borehole walls. A flexible probe is inserted into the access tube and a one millisecond pulse of electricity transmitted. The movement of the pulse through the magnetic fields set up by the magnets in the reference points induces a sonic pulse to travel back down the probe to the readout box, which then determines the distance between each magnet as a function of the time between the arrival of each pulse.

The instrument will be a reliable and powerful addition to the strata control instrumentation available at CBCRL, and in order to fully assess its capabilities the following test programme has been proposed, subject to obtaining the appropriate permissions.

COR-P/R Convergence Meter

The existing methods of monitoring convergence in gateside packs on longwall coalfaces, namely the M.R.E. Pack Strut is not compatible with modern strata control instrumentation concepts, typically remote monitoring or data logging. In addition, the M.R.E. Pack Strut was cumbersome and time consuming to install and was prone to early failure.

Thus, after consultation with several rock mechanics instrumentation manufacturers five pack struts of novel design were commissioned from Roctest Limited of Montreal. The new pack struts and electronic readout were designed to the following specifications:

Length	2.133 m	(7 ft)
Accuracy	0.254 mm	(0.01 in)
Range	0.914 m	(3 ft)
Repeatability	0.1%	
Operating Range	0-50° C	
Potentiometer Resistance	1000 Ω	

- All cables for transducer to have an inductance of less than 6.5 mH and capacitance less than 4.0 F
- Resin encapsulation of power supply circuitry
- Resistors to be of metal film, metal oxide or wire wound construction

- Diodes included to absorb high transient voltages resulting from possible collapse of transformer fields
- Current limiting resistors inserted to prevent overheating of components under adverse conditions and to protect the battery
- Burstproof case with dust seal to protect electronics
- Notice on box "Batteries not to be changed underground"
- Digital readout in metric
- All transducers and readout to be calibrated before delivery

General

- No external aluminium or incendive light alloy components on readout box or convergence meter

The complete strut is illustrated in Figure 3. The readout box reads convergence directly in centimeters, but a small calibration factor must be applied due to slight differences in strut construction.

Proposed Trials Programme

The location for the trials at Prince mine was chosen for ease of installation and convenience in monitoring. The extensometer and the convergence monitors would be installed in the coal road of the 3E longwall, as shown in Figure 4 and monitored to determine convergence and yield zone formation as the coalface approaches.

The preferred site would be 120-250 m in advance of the longwall in order to monitor the instruments over a comparatively stable period, thus providing valuable detailed information on the stability of the instruments.

This proximity to the face line will also allow front abutment effects to be monitored within a reasonable period of time.

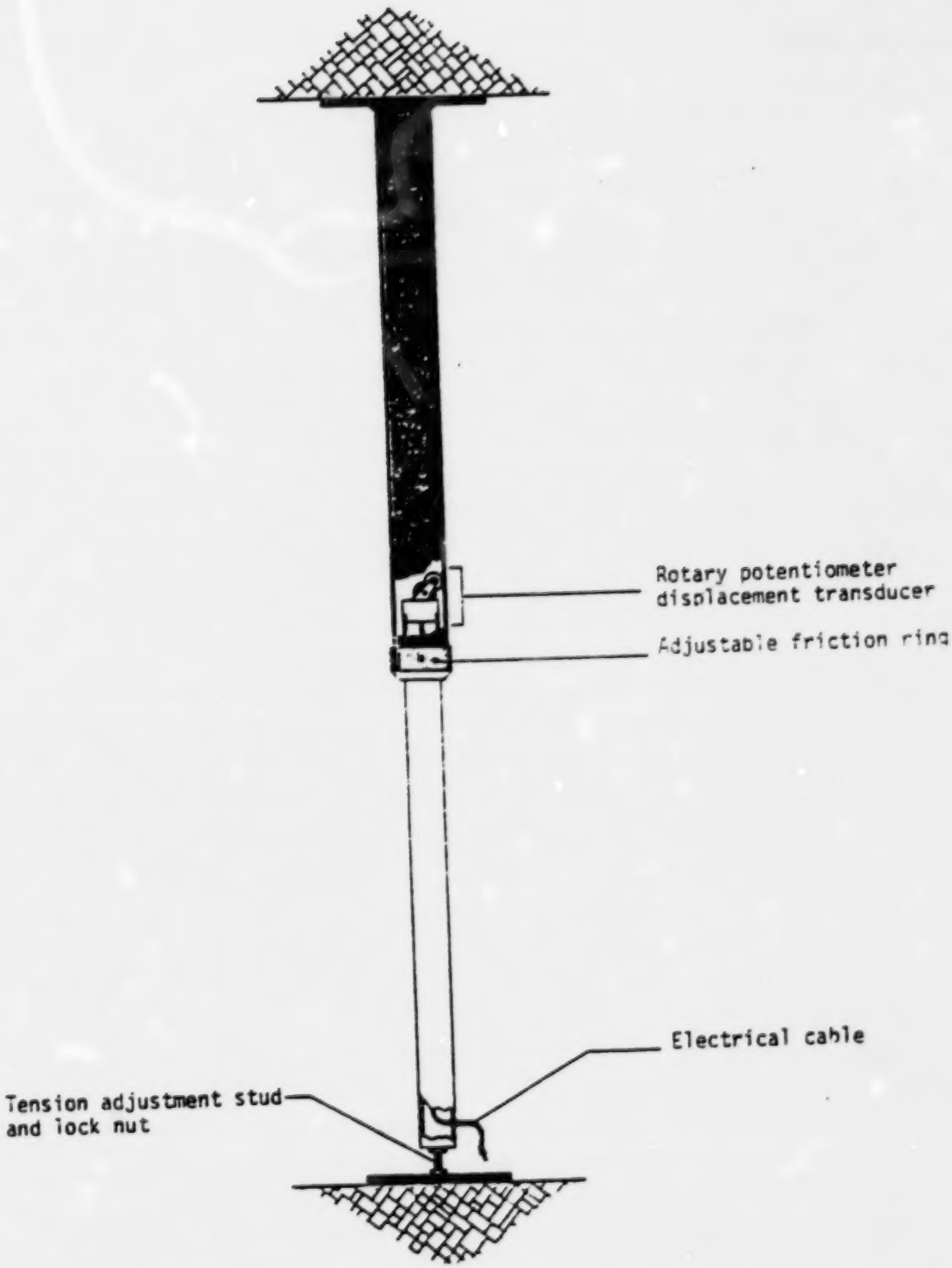

Fig. 3 COR-P/R Pack Strut

Installation

1. Irad Gage Extensometer

Two installations are planned. It is proposed that the holes required be drilled with a hand held coal auger or a Pegasus machine to a depth of 7.5 m in the face and rib sides.

A drilling machine, extendable drill rods of suitable diameter, fittings to power source and two drillers and a fitter will be required for approximately half of one shift. CBCRL staff will then install the in-hole instrumentation.

2. Convergence Meters

Four convergence meters will be installed, two each on the face and rib sides. Installation will take approximately 15 minutes per meter. In case it is necessary to stop the gate belt in order to install the rib side meters, it is planned to install the meters between shifts or on the weekend.

Monitoring

The instrumentation would be monitored by CBCRL staff at regular intervals, more frequently as the face line approached the site.

As long as the rib extensometer hole was drilled at a convenient height, both rib and face side instrumentation could be monitored safely from the travelling way without having to stop or cross the gate belt.

Results

Convergence results from the meters will allow predictions of yield zone formation to be made. These predictions will be tested by the extensometer results, and if correct will allow the extension of the technique.

In addition, the trials will provide valuable experience in two new instrumentation types, which will be widely used in the coalfield. Experience gained and lessons learned from this installation will greatly assist in planning larger investigations in future years.

ROOF FALLS AT PRINCE MINE

The nature of the roof fall problem at Prince mine was reviewed in the Quarterly Report of December 1982 (4), and a roof fall occurrence of November 2, 1982 was described.

At a meeting which followed the inspection of the fall site by CBCRL, CBDC and Labour Canada personnel, it was suggested by CBCRL staff that the following action be taken:

1) Convergence stations be established at intersections in the unstable area (a commercially available monitor registers convergence rates and will sound an alarm if the rate of closure indicates an incipient fall),
2) Consideration be given in future rehabilitation work to removing floor material rather than weakening the roof beam by ripping operations, and
3) Care be taken in all repair work in the unstable area, particularly at junctions and in areas of previous roof fall.

On June 8, 1983 a further roof fall occurred as ripping operations in a rectangular section cross cut approached No. 3 Deep in the unstable area. No. 3 Deep had previously suffered a collapse and was supported on arches at this location. The roof fall covered much of the main conveyor drive structure and halted production for two days. There were no injuries.

A CBCRL staff member visited the fall on June 10, 1983 and noted the following points:

1) the top of the fall zone was the base of the upper sandstone unit,
2) previous ripping operations in the deep had disrupted the lower sandstone unit, thus creating the unstable situation,
3) wood chock support above the remaining arches indicated that the overlying beds had separated prior to the fall and were being supported by the arches, and

4) as the contractor in charge of the work approached No. 3 Deep, he removed the legs of the arches on the cross cut side without bracing the arches, initiating the fall.

As a result of these investigations, the following recommendations are made:

1) Convergence stations should be established at intersections in the unstable area,
2) Consideration should be given to dinting rather than ripping to try to maintain a competent roof beam,
3) Considerable care should be taken in all repair work in the unstable area, particularly at junctions and in areas of previous roof falls,
4) Contractors should be made aware of previous problems and should make suitable support arrangements when approaching junctions in the unstable area, and
5) If ripping as opposed to floor dinting is preferred in the unstable roof area, a square cross section (i.e. rip to the base of the lower or upper sandstone unit) should be considered.

NO. 26 COLLIERY

The only activity at No. 26 Colliery in the last three months has been the trial of 'Swellex' roof bolts as a replacement for the more conventional approach of steel dowels (untensioned resin bolts). The results of a brief investigation of the relative properties of 'Swellex' and steel dowels are presented below.

COMPARISON OF ROOF BOLT TYPES

Difficulties encountered with rebar dowels at some locations within CBDC prompted the search for alternatives. Thus a series of comparison tests between 'Swellex' bolts and rebar dowels were conducted in the 13N coal road at No. 26 Colliery. Details of 'Swellex' bolts from manufacturer's literature are given in Appendix A.

Investigation Site

Holes for both bolt types were drilled into the siltstone above the coal on the low side of the gateroad. Samples of the siltstone, a medium grey rock with a fairly high mud content, plentiful fossils and carbonaceous parting planes were taken and the cone indenter strength index derived. These results gave a rock strength of 98-140 MPa, which appears high. One possible explanation is that the conversion factor was derived for rocks of the British coal measures succession. The competency of the rock, using the Q-system devised by Barton (5) was 1.33.

Bolt holes were drilled approximately normal to the bedding using a compressed air stoper drill.

Testing Programme

Four swellex bolts and five rebar dowels were tested. Several variations in bolt length and anchorage were tested, as detailed in Table 3. Results are given in Table 4.

Swellex Bolts	
#1	Normal 5 bolt. Pulled from bolt collar
#2	Bolt burst during installation (approximately 1 in 100 chance). 0.3 m of bolt was left outside the hole to allow a more elaborate pulling arrangement to be used
#3	Normal bolt, tested as #2
#4	As #3
Rebar Dowels	
#5	1.5 m rebar, 3 resin capsules, 20 sec spin
#6	1.5 m rebar, 5 resin capsules, 30 sec spin
#7	1.5 m rebar, 4 resin capsules, 40 sec spin
#8	1.5 m rebar, 3 resin capsule, 30 sec spin*
#9	1.5 m rebar, 4 resin capsule, 40 sec spin*

*spun using an impact wrench. Other spun with Stoper

Table 3. Details of Rock Bolt Tests at No. 26 Colliery

Swellex Bolts	Failure Load (tonnes)	Notes
1	9	bolt inflation collar failed
2	9	short bolt: penetration of loading ring
3	12	normal bolt: penetration of loading ring
4	14	normal bolt: no penetration of loading ring
Rebar Dowels		
5	6	bolt pulled out
6	15	bolt head stripped
7	20	no bolt movement
8	18	bolt head stripped
9	25	no bolt movement seen

Table 4. Results of Rock Bolt Tests at No. 26 Colliery

Discussion

Two factors must be considered before too much emphasis is placed on these results:

1) The pull test only gives an indication of relative bolt/anchor strengths, and this only if anchor conditions are controlled.
2) Too few tests were conducted to be sure of any statistical confidence.

It appears that properly installed rebar dowels are superior to 'Swellex' bolts, but that the 'Swellex' bolts appear to have a more consistent pullout load.

In order to further analyze the performance of the two bolt types, further testing is planned at both No. 26 and Lingan Collieries, where both types of bolts are currently being used to support the roof of longwall coalfaces prior to the removal of the powered supports.

THE DONKIN-MORIEN PROJECT

Work currently being undertaken at Donkin-Morien can be divided into two main sections:

Rock/Support Interaction Studies

Mine Water Studies

ROCK/SUPPORT INTERACTION STUDIES

Throughout the period April to June 1983, work continued on the unsolicited proposal submitted by Golder Associates to monitor rock/support interaction in the access drivages of the Donkin-Morien project.

In April, the necessary equipment for undertaking in situ stress measurements in the No. 3 drivage was assembled. This part of the work included all the necessary modifications and/or protective devices required for certification of the equipment prior to use.

In May, the initial series of in situ stress determinations were undertaken in the sandstone unit of the No. 3 drivage. Stress measurements were made using both the USBM and CSIRO gauges consecutively at intervals within the borehole. An initial examination of the results shows that although the USBM tests generally behaved in a 'textbook' manner, some

difficulty was experienced with the CSIRO tests.

During June, the laboratory work associated with the in situ determination work was completed and an investigation made of the CSIRO gauges which produced spurious results. In each case, the overcore was sectioned and a detailed examination made of the defects in bonding between the gauge and the host rock.

A preliminary analysis suggests that the valid CSIRO tests are consistent with those of the USBM. Similarly, vertical stresses measured in the sandstone unit appear to be in reasonable agreement with the static vertical stress (calculated from the weight of overburden) at the point of measurement. It is expected that a draft report covering all aspects of the in situ stress work carried out in the No. 3 drivage will be completed by early August. Results from this work will be reported when available.

MINE WATER STUDIES

Minor water inflows have been experienced in several sections of the No. 3 tunnel. A reassessment of the available data is currently in progress i.e. hydrochemical data, tunnel inflows and piezometric levels. In addition, hydrochemical data from the undersea coalfield workings of North-East England has been obtained and is currently being analyzed for comparison with the Donkin data and eventual inclusion in the mine water data base for the Sydney Coalfield.

Sampling of the Donkin fresh water well has continued in order to monitor the progress of the salt water intrusion. Figure 4 shows data from the well for the period March 22 to May 12 plotted on a Durov diagram. Also plotted on Figure 4 are samples of seawater and 'fresh' water from chainage 396 in the No. 3 drivage. Figure 5 shows the same well points plotted on an enlarged section of a Durov diagram. In Figure 5, it appears that the well water quality improves until the middle of April after which it appears to stabilize. The change in consistency from a saline to less saline water can be explained by two interrelated mechanisms:

Data Points

Nos.

1	Ch 396	
2	Well Water	22-03-83
3	Well Water	30-03-83
4	Well Water	07-04-83
5	Well Water	15-04-83
6	Well Water	29-04-83
7	Well Water	12-05-83
8	Ch 400	
9	Ch 500	
10	Seawater	

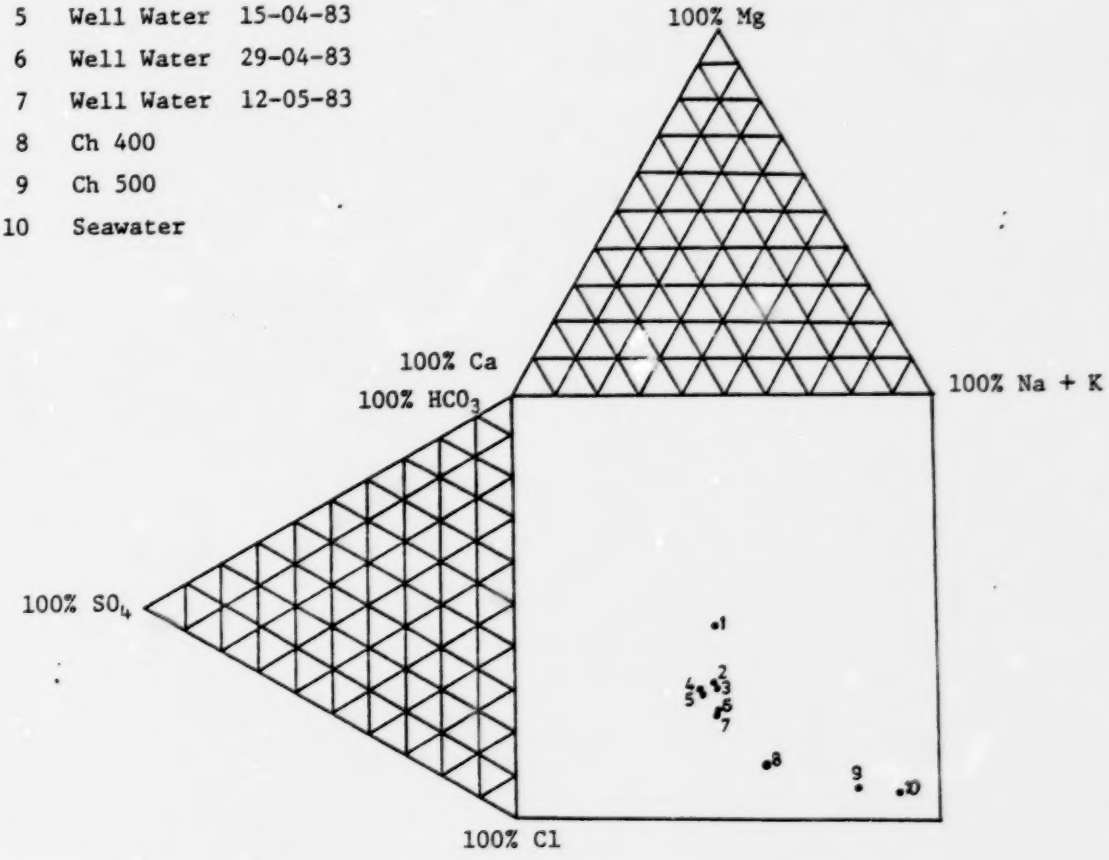

Figure 4 Durov Diagram, Well Water, Seawater and Tunnel No. 3 Samples, Donkin-Morien Project.

Data Points

Nos.

2	Well Water	22-03-83
3	Well Water	30-03-83
4	Well Water	07-04-83
5	Well Water	15-04-83
6	Well Water	29-04-83
7	Well Water	12-05-83

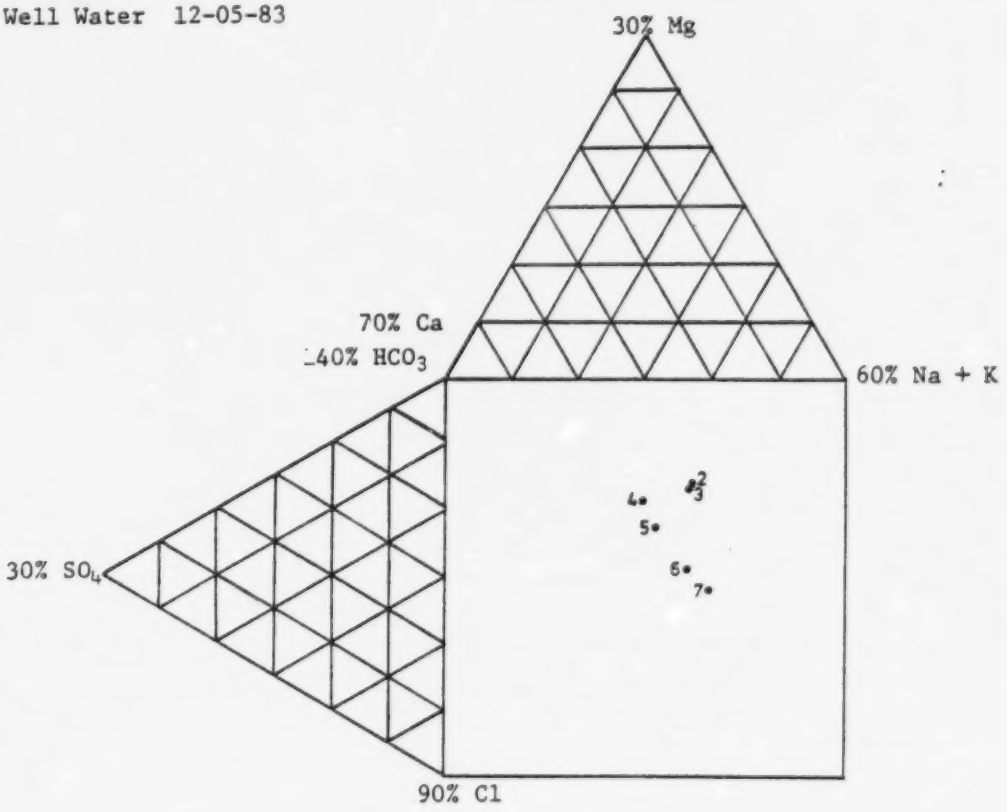

Figure 5 Durov Diagram, Enlarged Section - Well Water Samples, Donkin-Morien Project.

1) Since only routine maintenance and inspection were undertaken at the site during this period, less water was pumped from the well. In turn much smaller quantities of saline water have been drawn into the area of greater 'hydraulic gradient' surrounding the well.
2) More importantly, since only small quantities of water have been pumped, freshwater recharge resulting from the downward percolation of rainfall and snow melt will have both displaced and diluted the proportion of saline water in the well vicinity.

SUBSIDENCE RESEARCH IN THE SYDNEY COALFIELD

Existing guidelines for the safe working of undersea coal reserves suggest that between 8.75 mm/m (N. America) and 10 mm/m (U.K.) of tensile strain associated with subsidence formation can be induced at seabed before the risk of water occurrences to mine workings becomes unacceptable. The applicability of existing guidelines to the Sydney Coalfield is uncertain, since they were derived from land truthed data which has been extrapolated to undersea conditions, rather than derived empirically from seabed truthed data.

A document entitled 'Discussion Paper: Subsidence Research in the Sydney Coalfield' (6) has been circulated within CBDC and CANMET and some comments received. In view of the comments received, the first phase of the programme has been commenced:

1) Detailed literature search.
2) Evaluation of existing subsidence criteria within the Sydney Coalfield.
3) An examination of potential instrumentation schemes for monitoring the formation of subsidence profiles and their associated zones of tensile and compressive strain at seabed.

APPLICATION OF GEOSTATISTICS TO THE SYDNEY COALFIELD

At a meeting held on January 13, 1983 between members of the CBCRL Strata Mechanics group and personnel from CBDC, NOVACO and the N.S. Dept. of Mines and Energy (NSDME) the application of geostatistical techniques* to the Sydney Coalfield were raised. Further to this meeting and after subsequent discussions with NOVACO and NSDME personnel it was decided to assess whether geostatistical techniques could be applied to the problems and conditions existing within the Sydney Coalfield. A three day visit was therefore made to the Mine Evaluation Group (MEG), MRL Ottawa by CBCRL personnel and as a test case data from the NOVACO Point Aconi open pit site input to the Mine Evaluation Group's GEM (Geostatistical Evaluation of Mines) suite of programmes. A report (8) has since been written which describes the sequence of operations performed on the Point Aconi data when using the GEM system programmes. Examples of semi-variogram analysis and kriging are given, although a detailed evaluation of the site was not possible due to a lack of time.

In conclusion, the report (8) discusses the direction that any future research programmes should take regarding the use of geostatistics in the Sydney Coalfield. In particular, it is suggested that a dual-purpose programme should be established to undertake both the resource/reserve evaluation of mineral areas and develop the use of geostatistics in the field of strata mechanics.

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*In this context geostatistics is referred to as the 'Theory of Regionalized Variables' or a method for producing the best estimate of an unknown value at some location within a mineral body using the technique of kriging (7).

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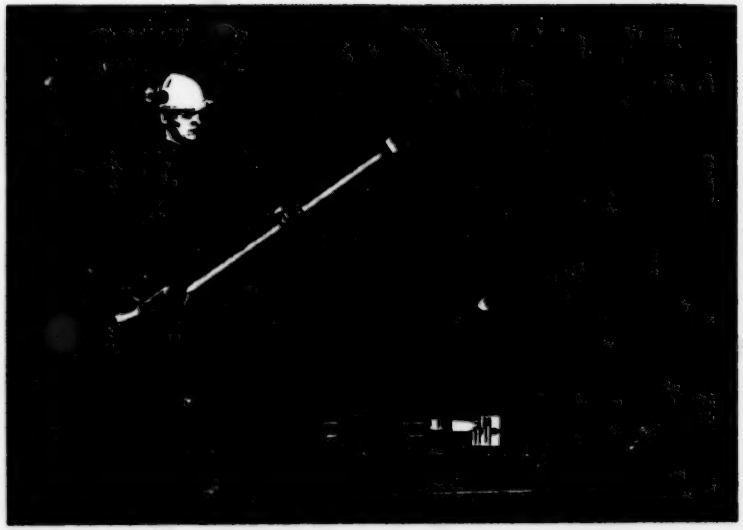
APPENDIX A



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Pneumatic water booster pump suitable for mobile use. The pump is connected to the ordinary water and air systems at the jobsite. A separate water reservoir can also be used.

The standard pump designated Swell A660 AI, is also available i a flame-proof version.

Technical data

Tensile strength min.	100 kN	10 tons	11 tons (US)
— Test result	100—120 kN	10—12 tons	11—13 tons (US)
Bushing end strength min.	100 kN	10 tons	11 tons (US)
— Test result	100—150 kN	10—15 tons	11—17 tons (US)
Pull-out force per length unit	100—200 kN/m	10—20 tons/m	3,5—7 tons (US)/foot
Water pressure	30 MPa	300 bar	4300 psi
Recommended drill bit size	38 mm	38 mm	1 1/2"
Bolt lengths	0,6—3,6 m in intervals of 0,3 m	0,6—3,6 m in intervals of 0,3 m	2'—12' in intervals of 1'

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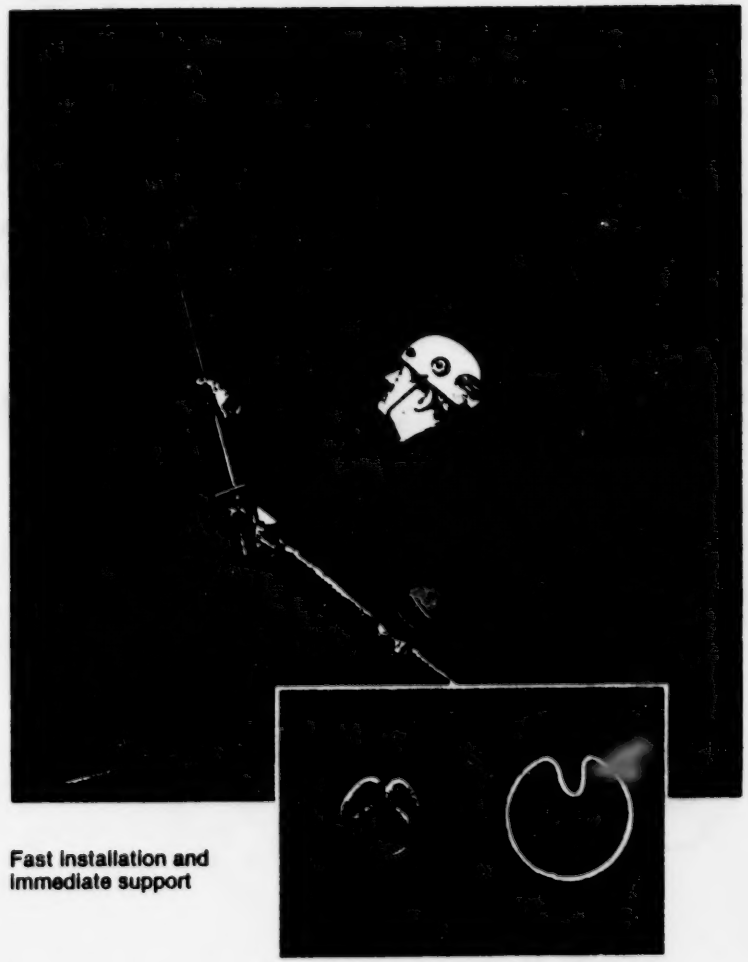

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25 A

for immediate